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## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates generally to the fields of semiconductor manufacturing. More specifically, the present invention relates to process chamber lid open equipment.

### Description of the Related Art

During chemical vapor deposition (CVD) processing, reactive gases released inside a process chamber form layers, such as silicon oxides or nitrides, on the surface of a substrate being processed. During this process, oxide/nitride deposition occurs

elsewhere in the CVD apparatus. The oxide/nitride residue has a deleterious effect on the CVD process if the CVD apparatus is not periodically cleaned. To avoid these deleterious effects, periodic cleaning procedures are undertaken to remove the oxide/nitride residue every  $N$  wafers/substrates, where  $N$  is an integer.

The cleaning procedures, however, result in periodic down-time for the CVD system, thereby reducing the system throughput. To reduce the total down-time of the CVD system, two types of cleaning techniques are employed: a gas-clean technique and a wet-clean technique. During a gas-clean technique, a cleaning gas, such as oxygen, NF<sub>3</sub>, helium and/or nitrogen, is flowed into the process chamber to remove oxide residue present therein. The gas-clean technique is achieved without breaking the vacuum seal of the process chamber, the seal being formed when a lid associated with the process chamber is in a closed position. This technique minimizes the amount of down-time necessary to perform the cleaning procedure. The gas-clean technique is unable to remove a portion of the oxide residue present in the CVD system, necessitating a periodic wet-clean technique. During a wet-clean technique, the vacuum seal of the process chamber is broken by moving the chamber lid to an open position. A user physically wipes down the chamber using chemical cleaners. Thus, the wet-clean technique is substantially more time-consuming than the gas-clean technique, thereby increasing the down-time of the CVD system.

The prior art is deficient in the lack of a CVD system which may reduce the time required for wet-cleaning. Specifically, the prior art is deficient in the lack of integration of lid open equipment at each CVD process chamber, which is capable of 5 moving the process chamber lid up/down (open/close condition) and rotating the lid 180 degrees. The present invention fulfills this long-standing need and desire in the art.

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## SUMMARY OF THE INVENTION

In one aspect of the present invention, there is provided 15 is a lid assembly for a chemical vapor deposition (CVD) process chamber, comprising a moveable lid, two linear guide rollers, one or more linear lifting actuators, and a rotation actuator. Optionally, the lid assembly may comprise one or more gas springs to support the weight of the lid. The two linear guide rollers are parallel to 20 each other and both are connected to the lid, one on each end of the axis of the lid. The linear lifting actuators move the lid up and down along the linear guide rollers, while the rotation actuator is connected to the axis of the lid and rotates the lid once the lid is lifted to a upper limit. This lid assembly may be used for 25 opening/closing process chamber in chemical vapor deposition (CVD) processes.

In another aspect of the present invention, there is provided is a method of wet-cleaning the process chamber in a chemical vapor deposition procedure. This method comprises the steps of (1) lifting the process chamber lid up by linear lifting actuators; (2) rotating the lid 180 degrees on the axis by a rotation actuator; (3) lowering the lid to below the process chamber, thereby breaking the vacuum seal of the process chamber; and (4) wiping down the chamber using chemical cleaners. During step (1), the lid is moved along linear guide rollers, which are connected to the axis of the lid.

Other and further aspects, features, and advantages of the present invention will be apparent from the following description of the embodiments of the invention given for the purpose of disclosure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

So that the matter in which the above-recited features, advantages and objects of the invention, as well as others which will become clear, are attained and can be understood in detail, more particular descriptions of the invention briefly summarized above may be had by reference to certain embodiments thereof which are illustrated in the appended drawings. These drawings form a part of the specification. It is to be noted, however, that the appended

drawings illustrate embodiments of the invention and therefore are not to be considered limiting in their scope.

**Figure 1** is an over view of process chamber lid open mechanism showing lifting linear actuator 101, linear guide roller 102, gas spring 103, spur gear reduction 104, gear 105 with a cover (at removed condition), rotation actuator 106, motor controller 107 and a moveable lid 108.

**Figures 2A-2C** show process chamber lid open mechanism operation steps, wherein the lid is first lifted up (**Figure 2A**), rotated 180 degrees (**Figure 2B**) and then lowered 600 mm (**Figure 2C**).

**Figure 3** is a side view of lid working area demonstrating process chamber lid open mechanism dimension.

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## DETAILED DESCRIPTION OF THE INVENTION

Provided herein is a process chamber lid open/close equipment, comprising a moveable lid 108, two lifting linear actuators 101 (one on each end of the axis of the lid), two linear guide rollers 102 (one on each end of the axis of the lid), two gas springs 103, spur gear reduction 104, gear 105, a rotation actuator 106, and a motor controller 107 (Figure 1). The dimension of the process chamber lid open mechanism is further shown in Figure 3.

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A lid open/close mechanism is constructed with linear guide rollers 102 and linear lifting actuators 101. The lid is supported at the linear guide rollers 102 and operated up or down by lifting linear actuators 101 to a upper (open) or lower (close) limit. Two lifting linear actuators 101 are installed at both ends of the axis of the lid so that the linear actuators do not inhibit to access below process chamber. Process chamber has a controller and related equipment in the middle lower portion. Some indicator and switch are constructed for the control. No equipment is allowed to block/cover the surface of the control panel. Lid weight is supported by two gas springs 103 to reduce the load of rotation actuator 106.

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25 A lid rotation mechanism is constructed with gear 105 and rotation actuator 106 connected to the movable lid 108. The lid rotation mechanism is not operational unless the lid reaches to the upper limit.

Such integration of lid open equipment at each chemical vapor deposition (CVD) process chamber is capable of moving the process chamber lid up/down (open/close condition) and rotating 5 the lid 180 degrees.

Compared with conventional lid open/close and rotation mechanisms, the presently disclosed process chamber lid open mechanism is easy for lid maintenance such as wet cleaning shower head and/or process chamber. The lid can be lowered from 1.8 m 10 to 1.2 m at shower head surface from floor level. Additionally, the present lid open equipment makes it easier to disconnect radiofrequency (RF) power, signal cable and cooling water, since the lid can be lifted straight up.

To operate the process chamber lid open equipment disclosed herein, the lid is first lifted up to the upper limit (Figure 2A), then rotated 180 degrees (Figure 2B) and last lowered 600 mm (Figure 2C).

As described above, provided herein is a lid assembly for chemical vapor deposition (CVD) process chamber, comprising a moveable lid, two linear guide rollers, one or more linear lifting actuators, and a rotation actuator. Optionally, the lid assembly may 25 comprise one or more gas springs to support the weight of the lid. The two linear guide rollers are parallel to each other and both are connected to the lid, one on each end of the axis of the lid. The

linear lifting actuators move the lid up and down along the linear guide rollers, while the rotation actuator is connected to the axis of the lid and rotates the lid once the lid is lifted to the upper limit. Specifically, the lid can be lowered up to 600 mm by the linear lifting actuators and rotated up to 180 degrees by the rotation actuator.

The presently disclosed lid assembly may be used for opening/closing the process chamber in chemical vapor deposition (CVD) processes. Specifically, the process chamber is in an open condition when the lid is moved up by the linear lifting actuators to a upper limit, whereas the process chamber is in a close condition when the lid is moved down by the linear lifting actuators to a lower limit.

Also provided herein is a method of wet-cleaning a process chamber in chemical vapor deposition. This method comprises the steps of (1) lifting up the process chamber lid by linear lifting actuators; (2) rotating the lid 180 degrees on the axis by a rotation actuator; (3) lowering the lid to below the process chamber, thereby breaking the vacuum seal of the process chamber; and (4) wiping down the chamber using chemical cleaners. During step (1), the lid is moved along linear guide rollers, which are connected to the axis of the lid.

Any patents or publications mentioned in this specification are indicative of the levels of those skilled in the art to

which the invention pertains. These patents and publications are herein incorporated by reference to the same extent as if each individual publication was specifically and individually indicated to be incorporated by reference.

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One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. It will be apparent to those skilled in the art that various 10 modifications and variations can be made in practicing the present invention without departing from the spirit or scope of the invention. Changes therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention as defined by the scope of the claims.

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